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CHARACTERISTICS OF SCIENCE/ENGINEERING EQUIPMENT IN ACADEMIC SETTINGS: 1989-90

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National Science Foundation

May 1991
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COMPLETED

HIGHLIGHTS

AMOUNT. In 1988-89, science/engineering departments and research centers at research-performing colleges, universities, and medical schools had $3.25 billion of movable equipment in the $10,000 to $999,999 price range.

DISTRIBUTION. This aggregate investment was distributed among five main types of equipment: computers (25 percent), spectrometers (22 percent), microscopes (8 percent), bioanalysis equipment (18 percent), and all other instrumentation (28 percent).

USAGE. All but 3 percent of these instruments were used partly or entirely for research, and only about one-in-five were expected to be converted to instructional use when no longer useful for research. However, graduate students and postdoctorates were the principal research users of this equipment (the average instrument system had 10 such users in 1988-89), indicating both widespread sharing and a significant educational component in the use of most academic research equipment.

AGE AND LIFE EXPECTANCY. The median age of 1988-89 academic research instruments was 3 years, and the median total research life expectancy was 11 years. On average, computers were younger, and had shorter research life expectancies, than other kinds of research equipment.

REPLACEMENT COST. The estimated cost of simply replacing instruments that institutions expect to be retired from research use in the 3 year period following the survey is $0.5 billion. Although equipment replacement costs are substantial, the primary factor driving institutions' future instrumentation expenditures was expected to be the need to acquire new generations of equipment to meet rapidly changing technological requirements for frontier research.

CAPABILITY AND CONDITION. Although 89 percent of research instruments were judged to have capabilities (power, resolution, etc.) that were "adequate to meet research users' needs," only 35 percent were considered to have "state-of-the-art" capabilities. Overall, 60 percent of research instruments were reported to be in generally "excellent" working condition.

AGE AND CONDITION. Of research instruments in the 0-2 year age range, three-fourths were reported to be in excellent working condition. Only 40 percent of those 6 or more years of age were in this condition.

CHARACTERISTICS OF SCIENCE/ENGINEERING EQUIPMENT IN ACADEMIC SETTINGS: 1989-90

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AVAILABILITY

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ACKNOWLEDGMENTS

The *Characteristics of Science/Engineering Equipment in Academic Settings: 1988-89* was conducted by Westat, Inc., under contract to the National Science Foundation (Contract Number SRS-8821876). Technical and financial support was also provided by the National Institutes of Health.

At the National Science Foundation, the survey was developed and guided by Judith F. Coakley and Eileen L. Collins, Senior Science Resources Analysts, Division of Science Resources Studies.

Paul Seder, National Institutes of Health, Office of Science Policy and Legislation, directed the National Institutes of Health components of the study.

The study also benefitted from the advice of an expert advisory panel. As well as providing many useful recommendations for the design and conduct of the study, several members of the current advisory panel made significant contributions to the development of the equipment classification taxonomy that is used in the data analysis. The members of this panel are named on the inside back cover of this report.

The burden of the study's extensive data collection activities was borne largely by the institution-appointed survey coordinators at the 79 sampled institutions, to whom we owe a special debt of gratitude. The institutions that participated in the survey are listed in Appendix A.

SUGGESTED CITATION

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EXECUTIVE SUMMARY

This monograph is one in a series of analytical reports presenting findings from the National Science Foundation's 1989-90 National Survey of Academic Research Instruments and Instrumentation Needs. It describes the current (1988-89) stock of movable* science/engineering equipment in the $10,000 to $999,999 price range at the nation's research-performing colleges, universities, and medical schools. The text summarizes study findings concerning the amount, cost, age, and other characteristics of five major types of equipment (computers, spectrometers, microscopes, bioanalysis equipment, and all other equipment). Appendix tables present more detailed information for 28 types and subtypes of equipment.

The findings are based on multistage samples of 11,575 instruments from 1,188 science/engineering departments and research centers at 79 institutions: 55 colleges and universities and 24 medical schools. The study is limited to equipment assigned to academic departments and research centers in engineering, chemistry, physics/astronomy, and the agricultural, biological, computer, and environmental sciences. The sample data are statistically weighted to represent a universe of institutions that collectively account for over 90 percent of the nation's academic R&D expenditures in the above fields. The survey response rates are 90 percent or more at all sampling levels.

This triennial equipment survey program is funded jointly by the National Science Foundation (NSF) and the National Institutes of Health (NIH) and is conducted in response to a Congressional directive to the Foundation to: "*...develop indices, correlates or other suitable measures or indicators of the status of scientific instrumentation in the United States and of the current and projected needs for scientific and technological instrumentation*" (P.L. 96-44, Section 7).

Equipment Amount and Usage

In 1988-89, research-performing colleges, universities, and medical schools as a group had an estimated 82,000 instrument systems in the $10,000 to $999,999 price range in the science/engineering fields encompassed by this survey. The aggregate purchase price of this equipment was about $3.25 billion. This aggregate investment was distributed as follows:

- Computers and data handling equipment: $814 million (25 percent);
- Spectroscopy and light measurement equipment: $708 million (22 percent);
- Microscopes and accessories: $255 million (8 percent);
- Bioanalytical instruments (centrifuges, chromatographs, DNA synthesizers/sequencers, scintillation counters, etc.): $572 million (18 percent); and
- Other equipment (electronics, lasers, temperature/pressure control equipment, etc.): $905 million (28 percent).

Most of this equipment was used entirely (63 percent of the instruments) or primarily (29 percent) for research. Only 3 percent of the $10,000 to $999,999 equipment items inventoried to science/engineering departments and centers represented in this survey were dedicated for instructional use. The remaining 5 percent were used predominately but not entirely for instruction.

Of the equipment that was used partly or entirely for research, comparatively little (19 percent) was targeted for conversion to instructional use when it is no longer useful for research. On the other hand, graduate students and postdoctorates were the principal research users of all five major categories of equipment, suggesting that most academic research equipment served educational as well as purely research functions.

Most academic research instruments were shared among several faculty and graduate student/postdoctorate researchers. In 1988-89, the overall average annual number of research users per system was 17, 10 of whom were graduate students and postdoctorates in the department/center to which the instrument was assigned. For computers, the overall average was 31 users; the average ranged from 11 to 15 users for the other major types of equipment.

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*This study is limited to movable equipment. Fixed equipment, such as fume hoods, lab benches, cold rooms, and building infrastructure (central heating/cooling, plumbing, power, etc.), is covered in a separate NSF survey of academic research facilities.

Age and Life Expectancy

About 40 percent of the instruments in academic research use in 1988-89 had been acquired within the past 3 years, and an additional 30 percent were 3-5 years of age. Of the five major types of equipment, computers were the newest (87 percent were 0-5 years of age), while spectrometers and microscopes were the oldest (44-46 percent were 6 or more years of age).

Across all academic research instruments in the $10,000 to $999,999 range, the median expected useful research life[**] was 11 years. Computers had considerably shorter research life expectancies (median = 6 years) than most other categories of equipment. Of the major equipment types, microscopes had the longest research life expectancies (median = 15 years).

Replacement Cost

Within the 3 year period following the survey, 13,500 instrument systems in the $10,000 to $999,999 price range were expected to be retired from research use. At an average replacement cost of $40,000 per system (the mean purchase price of research instruments in the 1988-89 national inventory), the cost to replace these instruments will be about $0.5 billion.

For computers, which have relatively short research lives, the replacement cost in the 3 years following the survey (about $300 million) will represent about half of all expected expenditures for this type of research equipment. For other kinds of research instruments, which have longer life expectancies, the cost of replacing of obsolete or worn-out equipment (about $235 million, altogether) will represent only 9-17 percent of total expected research equipment purchases. According to department heads' reports of their top equipment priorities, future science/engineering equipment spending will be needed primarily to stay abreast of changing technologies at the frontier of research and, to a lesser extent, by a desire to expand capabilities by acquiring additional copies of existing instruments, rather than simply to replace outworn equipment.

Maintenance and Repair

Relatively few research instruments were covered under active warranties (18 percent) or service contracts (24 percent). Such prepaid maintenance/repair coverage was most common for computers (58 percent) and bioanalysis equipment (56 percent).

The cost of an initial warranty is generally built into the instrument purchase price. Once a warranty expires, maintenance costs must come from other sources. The average annual cost of service contracts in 1988-89 was $3,700 per system, or roughly 7 percent of the instrument's original purchase price. Average maintenance/repair expenditures for instruments not covered under service contracts were $700 per system, or about 2 percent of the original purchase price.

Capability, Condition, and Adequacy

Most instruments in research use were judged by their principal faculty users to have technical capabilities (resolution, speed, etc.) that were "adequate to meet research users' needs" (89 percent). A lower percentage was judged to be in "excellent" working condition (60 percent), and a still lower percentage was characterized as having "state-of-the-art" technical capabilities (35 percent). All of these assessments were affected by the age and, to a lesser extent, the type of instrument being evaluated. For example, the percentage of instruments assessed as being in excellent working condition ranged from 87 percent of microscopes in the 0-2 year age group to only 9 percent of computers in the 6 years or more age group.

[**] Life expectancy is defined as the instrument's current age, plus the user-reported estimate of the instrument's remaining years of useful research life.

INTRODUCTION

This report describes the composition and characteristics of the national stock of science/engineering equipment in academic settings. It is limited to movable equipment in the $10,000 to $999,999 price range in seven major fields of academic science/engineering: the agricultural, biological, computer and environmental sciences, chemistry, physics/astronomy, and engineering.

The data were obtained from the most recent (1989-90) cycle of the National Survey of Academic Research Instruments and Instrumentation Needs. This triennial survey program, conducted by the National Science Foundation (NSF) with major support from the National Institutes of Health (NIH), is designed to monitor emerging research equipment needs and trends in the amounts, costs, and characteristics of existing academic research equipment in a broad spectrum of science/engineering fields.

This is one in a series of reports presenting information from the 1989-90 survey. Other reports describe trends/changes in research instrumentation costs, amounts, and needs in various research fields and types of academic institutions.[1] The present report describes the most recent total stock of science/engineering equipment in greater detail, highlighting several kinds of information that were obtained for the first time in the 1989-90 cycle of the survey:

- The most recent database includes equipment used entirely for instruction, as well as equipment used partly or entirely for research, and information was obtained about the mix of research vs. instructional purposes for which equipment is used.
- In the latest survey, information was obtained not only about the age of individual equipment items, but also about the expected remaining useful research life of each item. This makes it possible to calculate items' total research life expectancies and to estimate the costs of replacing obsolete and worn-out equipment.
- For the first time in the survey program, all equipment has been classified by type (computer, microscope, etc.), which makes it possible to examine type-related differences in equipment usage, life expectancy, replacement cost, and other characteristics.

The results sections of this report present an overview of the national stock of science/engineering equipment in academic settings with respect to such characteristics as:

- The aggregate amount, unit cost, and distribution of equipment;
- The kinds and levels of equipment usage;
- The forms and costs of equipment maintenance;
- Equipment age, life expectency, and replacement cost; and
- The perceived quality and condition of existing research equipment.

In the text, these characteristics are discussed for the overall national stock and for major types of equipment. Additional detail for more specific categories of equipment (e.g., for specific types of spectrometers) is presented in appendix tables (see Appendix C).

Background

When numerous reports came to the attention of Congress during the late 1970s that the research equipment available to scientists and engineers in leading research universities was often inadequate to meet the needs of modern research, Congress turned to the National Science Foundation (NSF) for factual information. The Congress directed the Foundation to: *"...develop indices, correlates or other suitable measures or indicators of the status of scientific instrumentation in the United States and of the current and projected needs for*

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[1] See *Academic Research Equipment and Equipment Needs in Selected Science/Engineering Fields: 1989-90*, NSF, 1991. In addition, three other reports provide more detailed, disaggregated information about instrumentation trends within subfields of (a) the physical sciences, (b) the biological sciences, and (c) engineering/computer science. Copies of the biological sciences report may be obtained from the National Institutes of Health, Dr. Paul Seder, (301) 496-4418. Copies of the other reports may be obtained from the National Science Foundation, Dr. Eileen Collins, (202) 634-4673.

scientific and technological instrumentation."[2] In response, NSF initiated a feasibility study to determine the best sources of information about the amount, cost, condition, and need for academic research equipment. The National Survey of Academic Research Instruments and Instrumentation Needs was then developed on the basis of the information provided by the feasibility study. Since its inception, the survey has been funded jointly by NSF and NIH.

To date, three cycles of the survey have been completed using similar designs and data-gathering instruments. Cycle 1 was conducted in 1983-84; Cycle 2, in 1986-87; and Cycle 3, in 1989-90. Each of these cycles was conducted in two phases. During Phase I (in 1983, 1986, and 1989), information was collected for the physical and computer sciences and engineering. During Phase II (in 1984, 1987 and 1990), information was collected for the biological, agricultural, and environmental sciences, with the biological sciences portion of the data collection including a separately selected sample of medical schools in addition to the sample of nonmedical colleges and universities that provided data for all major science/engineering fields. Information about equipment dollar amounts and expenditures refers to the year preceding the survey.

Data Considerations

Basic parameters of the 1989-90 survey are described below. Previous cycles of the study used essentially the same parameters.

Institutions. The survey's institution sample consists of (a) 55 colleges/universities (excluding medical schools) selected to represent the 174 such institutions with 1984 nonmedical R&D expenditures of $3 million or more, and (b) 24 medical schools statistically selected to represent the 92 medical schools with 1982 NIH extramural funding of $3 million or more.[3] At each sampled institution, a study coordinator was identified to oversee all data collection activities.

Instruments. At each institution, inventory information was requested identifying all instrument systems originally costing $10,000 or more that were inventoried to departments and nondepartmental research centers in the science/engineering fields encompassed by the study. A total of 54,624 such instruments was identified, from which a sample of 11,575 was selected. For each one, the responsible principal investigator was asked to complete a short form concerning its cost, age, funding sources, condition, principal field of use, and other characteristics (see Appendix B). Very large instrument systems costing $1 million or more were excluded from this analysis.

Response Rates. Response rates in this voluntary survey were extremely high. All 79 sampled colleges/universities and medical schools participated in the 1989-90 survey (100 percent), and usable questionnaire responses were obtained for 90 percent of sampled instruments, continuing the high levels of participation established in earlier cycles of the survey.

Estimates. All findings discussed in this report are in the form of national estimates developed from the study samples. As well as reflecting institutions', departments', and instruments' original probabilities of selection, the estimates contain statistical adjustments for questionnaire nonresponse and imputations for item nonresponse within questionnaires, to ensure that reported estimates fully represent all intended institutions, fields, and instruments.

Sampling Errors. Since they are based on samples, the estimates presented in this report are subject to variability due to sampling error. For example, most overall estimates (not broken out by field) have sampling errors (coefficients of variation) of 2-6 percent, which implies a 95 percent confidence interval of about twice that magnitude: i.e., plus or minus 4-12 percent of the reported estimate.

Additional Information. Additional information about the study design, procedures, questionnaires, response rates, sampling errors, and other aspects of the survey methodology, is contained in a separate *Technical Notes* report.[4]

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[2] An Act To Authorize Appropriations for Activities for the National Science Foundation for Fiscal Year 1980, and for Other Purposes. Public Law 96-44, Section 7.

[3] The two institution sampling frames account, respectively, for over 90 percent of all nonmedical academic R&D expenditures, and for over 90 percent of all NIH extramural funding to medical schools. The 79 sampled institutions are listed in Appendix A.

[4] This report is available from the National Science Foundation. Contact Dr. Eileen Collins (202) 634-4673.

RESULTS

Amount and Unit Cost

In 1988-89, the 174 research-performing colleges and universities and 92 research-performing medical schools encompassed by this survey contained approximately 82,000 items (instrument systems) of movable science/engineering equipment in the $10,000 to $999,999 price range (Table 1).[5] The aggregate purchase price of this equipment was about $3.25 billion. The average (mean) was about $40,000 per system.

For this report, the 1988-89 national equipment stock was subdivided into five major type categories:

- *Computers and data handling equipment* (computers, for short) accounted for 25 percent of aggregate equipment investment. Within this general category, imaging equipment (graphics, computer-assisted-design, and image analysis equipment) and large computer systems in the $200,000 to $999,999 range accounted for considerably smaller shares of total investment (3 percent and 6 percent, respectively) than did the many smaller systems and components in the $10,000 to $199,999 range (16 percent).

- *Spectroscopy and light measurement equipment* (spectrometers, for short) accounted for another 22 percent of the national investment. Of the six specific subtypes of spectroscopy equipment listed, ultraviolet (including UV-VIS) spectrometers were the most numerous and had the lowest average price ($21,000); NMR spectrometers had the highest average price ($146,000) and accounted for the largest aggregate investment ($163 million). Mass spectrometers (including gas chromatograph mass spectrometers) also were notably high in both average price ($133,000) and aggregate investment ($122 million).

- *Microscopes and accessories* accounted for 8 percent of the total equipment investment. Electron microscopes, with an average price of $120,000, accounted for the bulk of this investment.

- *Bioanalytical instruments* (bioanalysis, for short) encompassed an additional 18 percent of total investment. This category includes six subtypes of equipment that are used primarily in the biological sciences. Centrifuges, with an average price of $29,000, were the most numerous of these, and they accounted for the largest aggregate investment ($197 million). Chromatographs, scintillation/gamma counters, and growth/environmental chambers, with average prices in the low $20,000s, were also widely used. DNA/protein synthesizers and sequencers and cell counters/sorters, with average prices in the low $70,000s, were less prevalent.

- All *Other* equipment, including miscellaneous electronics (cameras, recorders, etc.), temperature/pressure control equipment (ovens, cryostats, vacuum pumps, etc.), lasers, etc. accounted for the final 28 percent of total investment.

Throughout the remainder of this results section, findings are summarized for these major equipment groupings, with only occasional references to findings for specific subtypes. Readers who require detailed information about specific subtypes of equipment are referred to the tables in Appendix C.

Distribution Across Fields

The major types of equipment were *not* evenly distributed across science/engineering fields (Table 2). Thus, computers were heavily concentrated in engineering (36 percent of the total investment in computers) and computer science (21 percent). Spectrometers were concentrated largely in chemistry (48 percent); this was especially true for NMR spectrometers, where 76 percent of aggregate investment was in chemistry (Appendix Table 2A). Microscopes and bioanalysis equipment were found mostly in the biological sciences (65 percent and 77 percent, respectively). Equipment in the *other* category was most heavily concentrated in engineering (49 percent) and physics/astronomy (19 percent).

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[5] This study is limited to movable equipment. Fixed equipment, such as fume hoods, lab benches, cold rooms, and building infrastructure (central heating/cooling, plumbing, power, etc.), is covered in a separate NSF survey of academic research facilities.

Table 1. Aggregate amount and price of academic research/instructional equipment, by type of equipment*

Type of equipment	Instrument systems		Purchase price		
	Number	Percent	Mean	Aggregate	Percent
			(Dollars in thousands)		
Total	81,753	100	$39.8	$3,253,840	100
Computers and data handling equipment	18,363	22	44.3	813,821	25
Graphics/CAD/image analysis	2,659	3	39.5	104,929	3
Other systems ≥ $200,000	506	1	355.7	179,978	6
Other systems < $200,000	15,198	19	34.8	528,915	16
Spectroscopy and light measurement equipment	12,762	16	55.5	707,753	22
Electron/auger/ion scattering	963	1	100.2	96,487	3
Infrared/FTIR/laser Raman	1,162	1	55.3	64,235	2
Mass/GC-MS	922	1	132.6	122,283	4
NMR/magnets	1,118	1	146.0	163,184	5
Ultraviolet/UV-VIS	2,920	4	21.1	61,746	2
X-ray (diffractometers, etc.)	1,232	2	74.3	91,506	3
Other	4,446	5	24.4	108,309	3
Microscopes and accessories	5,490	7	46.4	254,875	8
Electron microscopes	1,238	2	119.6	148,090	5
Other microscopy equipment	4,251	5	25.1	106,784	3
Bioanalytical instruments	20,107	25	28.5	572,380	18
Cell sorters/counters, cytometers	330	<1	72.3	23,860	1
Centrifuges and accessories	6,783	8	29.0	196,548	6
Chromatographs and elemental analyzers	5,353	7	21.8	116,831	4
DNA/protein synthesizers/sequencers/analyzers	1,439	2	70.2	101,060	3
Growth/environmental chambers	1,893	2	25.4	48,113	1
Scintillation/gamma counters	4,309	5	20.0	85,970	3
Other	25,032	31	36.2	905,011	28
Electronics/cameras/recorders	5,124	6	25.6	131,091	4
Temperature/pressure control/measurement equipment	3,969	5	24.0	95,274	3
Lasers and optical/motion analysis equipment	4,318	5	46.4	200,151	6
Major prototype systems ≥ $100,000	633	1	240.2	152,052	5
Other systems < $100,000	10,987	13	29.7	326,443	10

*Data refer to instrument systems orginally costing $10,000 to $999,999 that were used for research and/or instruction in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences).

REFERENCE: Appendix Table 1.

NOTE: Details may not sum to totals because of rounding.

SOURCE: National Science Foundation, SRS

Table 2. Distribution of academic research/instructional equipment across science/engineering fields, by major type of equipment*

Field	Major type of equipment					
	Total	Computers	Spectrometers	Microscopes	Bioanalysis	Other
				(Dollars in millions)		
Total aggregate purchase price	$3,254	$814	$708	$255	$572	$905
				(Percent of aggregate purchase price)		
Total percentage	100%	100%	100%	100%	100%	100%
Engineering	27	36	8	21	6	49
Agricultural sciences	3	1	3	3	7	2
Biological sciences	29	11	22	65	77	9
Medical schools	16	6	12	34	44	5
Other settings	13	5	10	31	33	4
Chemistry	17	7	48	2	7	13
Computer science	5	21	<1	-	-	<1
Environmental sciences	8	10	10	7	1	8
Physics/astronomy	11	14	8	1	2	19

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research and/or instruction in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences).

REFERENCE: Appendix Table 2A.

NOTE: Details may not sum to totals because of rounding.

SOURCE: National Science Foundation, SRS.

Usage and Users

At the research-oriented institutions represented in this survey, only 3 percent of science/engineering equipment in the $10,000 to $999,999 price range was used exclusively for instruction in 1988-89 (Figure 1). However, a significant amount (34 percent) was used at least partly for instruction. The remaining 63 percent was dedicated for research use only. Bioanalysis equipment was most heavily dedicated for research, with only 2 percent of the instruments in this category being used predominately or entirely for instruction. Microscopes and computers were most often used at leastly partly for instruction. This was especially true for electron microscopes (66 percent) and computer systems in the $200,000 and over range (63 percent; Appendix Table 3).

Relatively little research equipment is converted to instructional use. Only about one-fifth of the instruments in research use in 1988-89 were expected to be converted to instruction when no longer useful for research (Table 3). Such conversion was most often anticipated for microscopes (30 percent); it was least often contemplated for bioanalysis equipment (11 percent).

Among systems that were used at least partly for research, computers had the largest average number of research users per year (31; Figure 2). Computer systems in the $200,000 and over range had especially large average numbers of research users (69; Appendix Table 4). For the other major categories of equipment, the average numbers of users ranged from 11 to 15. These figures indicate that, unlike the conventional stereotype of academic science being conducted mainly in the labs of individual faculty members, with the equipment being used solely by that one person and perhaps one or two of that person's graduate students, most research equipment in the $10,000 and over range is widely shared.

Table 3. Expected disposition of academic research equipment when no longer useful for research, by major type of equipment*

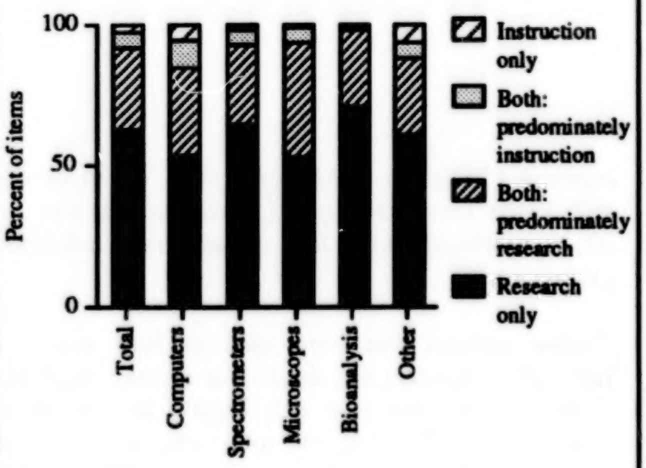
Expected disposition	Major type of equipment					
	Total	Computers	Spectrometers	Microscopes	Bioanalysis	Other
	(Percent of systems)					
Total	100%	100%	100%	100%	100%	100%
Used for instruction	19	18	22	30	11	22
Traded-in	32	32	25	47	44	23
Other/unknown	49	50	53	23	45	55

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

REFERENCE: Appendix Table 5.

SOURCE: National Science Foundation, SRS.

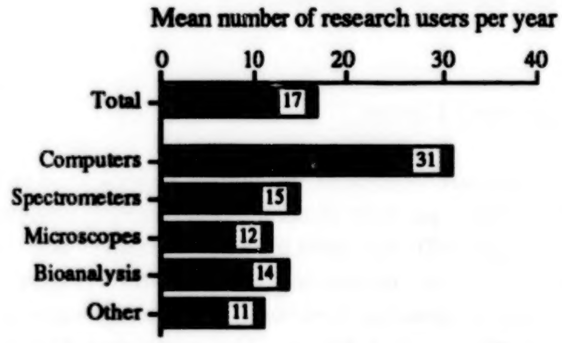
Figure 1. Usage of academic research/instructional equipment, by major type of equipment*



* Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research and/or instruction in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences).

Reference: Appendix Table 3
Source: National Science Foundation, SRS

Figure 2. Mean annual number of research users of academic research equipment, by major types of equipment*



* Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

Reference: Appendix Table 4
Source: National Science Foundation, SRS

Table 4. Current age of academic research equipment, by major type of equipment*

Current age	Major type of equipment					
	Total	Computers	Spectrometers	Microscopes	Bioanalysis	Other
	(Percent of systems)					
Total	100%	100%	100%	100%	100%	100%
0-2 years	38	52	28	27	32	40
3-5 years	31	35	28	27	33	28
6-8 years	13	7	18	18	13	14
9 or more years	18	5	26	28	21	18

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

REFERENCE: Appendix Table 6.

NOTE: Details may not sum to totals because of rounding.

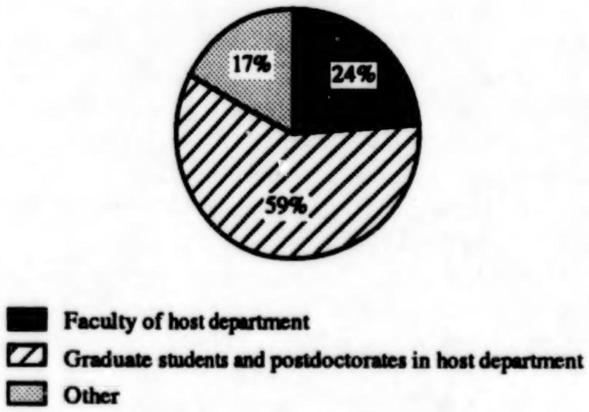
SOURCE: National Science Foundation, SRS.

For most categories of equipment, the user profile generally consists of 5-10 graduate students and postdoctorates and 2-3 faculty members from the department or research center where the instrument is located, plus 2-3 other users from outside the department/center (Appendix Table 4). Overall, only about one-fourth of most systems' research users were faculty members of the department or research center where the instrument is located (Figure 3). Graduate students and postdoctorates were the principal research users in all five equipment categories. This suggests that there is a discernable educational component in the usage of most academic research equipment, even though research may be the primary immediate purpose for which most equipment is used, most of the time.

Age and Life Expectancy

Overall, about 7 of every 10 instrument systems in research use in 1988-89 were acquired within the 5 previous years (Table 4). Almost 4 in 10 were under 3 years of age at the time of the survey. Computers were especially low in age: 87 percent were acquired within the 5 previous years, and over half (52 percent) were less than 3 years of age. At the other extreme, a majority of the electron microscopes in research use were 9 or more years old (51 percent), as were large proportions of the nation's scintillation counters (44 percent) and NMR spectrometers (35 percent; Appendix Table 6).

Figure 3. Types of research users of academic research equipment*



* Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

Reference: Appendix Table 4
Source: National Science Foundation, SRS

Table 5. Remaining research life of academic research equipment, by major type of equipment*

Expected years of remaining research life	Major type of equipment					
	Total	Computers	Spectrometers	Microscopes	Bioanalysis	Other
	(Percent of systems)					
Total	100%	100%	100%	100%	100%	100%
0-2 years	18	40	14	8	11	11
3-5 years	42	46	45	29	39	44
6-8 years	10	5	11	7	11	11
9 or more years	30	9	29	57	38	35

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

REFERENCE: Appendix Table 7.

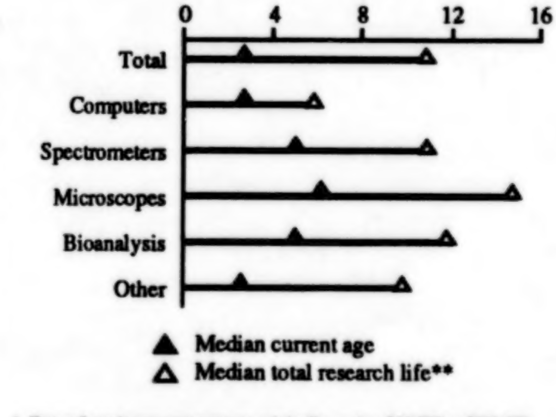
NOTE: Details may not sum to totals because of rounding.

SOURCE: National Science Foundation, SRS.

The current survey asked how many additional years of useful research service were expected from each instrument. This information, together with information about the instrument's current age, made it possible to calculate the instrument's total research life expectancy. Overall, the average (median) research life expectancy of academic research instruments in the $10,000 to $999,999 range was 11 years (Figure 4). Computers had the lowest average life expectancy (6 years); microscopes had the highest (15 years). Most other types and subtypes of equipment had average research life expectancies in the 10-12 year range (Appendix Table 8).

Overall, 60 percent of the instruments in research use in 1988-89 were expected to have less than 6 years of remaining useful research lives (Table 5). Again, most computers were seen as having few remaining years of useful research life: 86 percent were expected to last less than 6 more years, and 40 percent were expected to last less than 3 more years. At the other extreme (again) were microscopes, many of which (57 percent) were expected to continue in research service for at least 9 more years.

Figure 4. Median current age and total research life of academic research equipment, by major type of equipment*



* Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

** Total research life = current age + expected number of years of remaining useful research life.

Reference: Appendix Tables 6 and 8
Source: National Science Foundation, SRS

Table 6. Estimated replacement cost of academic research equipment expected to be retired within 3 years following the survey, by major type of equipment*

Index	Major type of equipment					
	Total	Computers	Spectrometers	Microscopes	Bioanalysis	Other
Number of systems to be retired in next 3 years	13,500	6,800	1,700	400	2,200	2,500
Mean purchase price per system (dollars in thousands)	$40	$45	$56	$47	$28	$37
Replacement cost (dollars in millions)**	$541	$306	$95	$18	$61	$91
Expected research equipment purchases in next 3 years***	$2,494	$624	$549	$200	$449	$672
Replacement cost as a percentage of total equipment purchases	22%	49%	17%	9%	14%	14%

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research and/or instruction in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Estimated replacement cost = number of systems with expected remaining useful research lives of 0-2 years times the mean purchase price of systems currently in research use.

***Estimated total in next 3 years = 3 times the level of equipment purchases reported in 1989-90; the total is allocated across types of equipment using the percentages shown in Table 1, right-hand column.

REFERENCE: Appendix Table 9.

NOTE: Details may not sum to totals because of rounding.

SOURCE: National Science Foundation, SRS.

Replacement Cost

At the time of the latest survey, the number of research instruments with expected remaining useful lives of less than 3 years was about 13,500. Assuming that these are worn out or obsolete instruments that will have to be replaced, at an average cost per system that is about the same as the average purchase price for existing systems (i.e., about $40,000 per system), it will cost roughly $0.5 billion to replace the equipment that will be retired from research use in the 3 years following the survey (Table 6). These replacement costs, while substantial, represent only about one-fifth of the overall equipment expenditures that will occur during this period if institutions maintain their most recent annual levels of purchases. This estimate is also consistent with reports from science/engineering department and research center heads, who indicated that most of their top priority instrumentation needs are intended to help them remain abreast of emerging technologies or (secondarily) to expand their research programs, rather than just to replace obsolete or worn out equipment.[6]

The overall estimate that replacement costs are likely to account for about one-fifth of total research equipment purchases in the 3 year period after the last survey does not apply evenly across the various categories of equipment. For computers, which have such short research life expectancies, replacement costs represented a very large fraction of total expected expenditures (49 percent; Table 6). At the other extreme, replacement costs for microscopes, which have very long life expectancies, constituted only 9 percent of expected equipment expenditures.

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[6] See *Academic Research Equipment and Equipment Needs in Selected Science/Engineering Fields: 1989-90*, National Science Foundation, Washington, D.C., 1991, 12.

Table 7. Provisions for maintenance/repair (M/R) of academic research equipment, by major type of equipment*

Provisions for maintenance/repair	Major type of equipment					
	Total	Computers	Spectrometers	Microscopes	Bioanalysis	Other
	(Percent of systems)**					
Total	100+%	100+%	100+%	100+%	100+%	100+%
Warranty	18	20	14	19	17	19
Service contract	24	38	11	19	39	8
Field services as needed	44	42	46	58	43	42
Institution M/R staff	40	43	48	26	28	48
Research personnel	47	33	57	50	39	59
Other	3	3	2	3	3	3

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**More than one provision may apply. Consequently, percentages sum to more than 100.

REFERENCE: Appendix Table 10.

SOURCE: National Science Foundation, SRS.

Maintenance/Repair Practices and Costs

Another significant cost associated with academic research equipment is the cost of equipment maintenance and repair (M/R). For many research instruments, needed M/R services during the year prior to the survey were "covered" under warranties that had been acquired at time of purchase (18 percent of current research equipment) or through separately purchased service contracts (24 percent; Table 7). However, the majority of instruments were serviced through field service calls, to outside service providers as needed, (44 percent) and/or through in-house servicing from specialized institution-employed maintenance personnel (40 percent) or from the research users of the equipment (47 percent). These percentages sum to more than 100, since more than one form of M/R may have been used (e.g., the equipment operators/users may have made some minor repairs themselves and may also have called in outside service providers when more complex problems arose).

Prepaid service coverage--through warranties and service contracts--was more commonly found for computers (58 percent) and bioanalysis equipment (56 percent) than for spectrometers (25 percent), microscopes (38 percent), or other equipment (27 percent).

It is difficult to document the cost of warranties, which is usually built into the instrument's purchase price. For instruments covered under service contracts, the average annual cost of the service contract was $3,700, 7.2 percent of the instrument's original purchase price (Table 8). The relative annual costs of service contracts were higher for computers (8.5 percent of original purchase price) than for the other four categories of equipment (all of which were around 6 percent). Average reported annual M/R costs for instruments not covered by service contracts were a considerably lower $700 per system, 2 percent of original purchase price.

Capability, Condition, and Adequacy

Only 35 percent of academic research instruments were characterized by the responsible principal investigator as being "state-of-the-art" (Figure 5). As one might expect, state-of-the-art status was strongly associated with equipment age, with older equipment seldom being given this designation. Even among systems that were less than 3 years of age, however, only about one-half were classified as state-of-the-art. Apparently, substantial amounts of academic research equipment are of a routine, workhorse nature and were not top-of-the-line/state-of-the-art even when they were new. This

Table 8. Annual expenditures for maintenance/repair (M/R) of academic research equipment as a percentage of system purchase price, by major type of equipment*

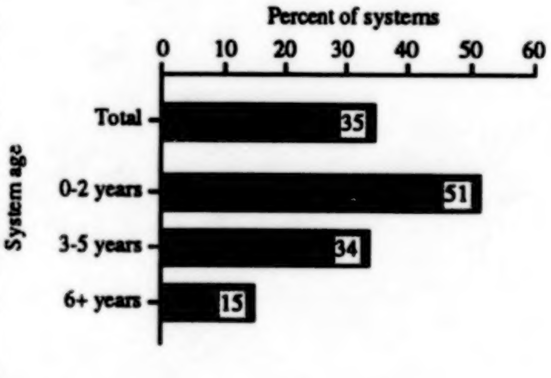
Provisions for maintenance/repair	Major type of equipment					
	Total	Computers	Spectrometers	Microscopes	Bioanalysis	Other
	(Annual M/R as a percent of system purchase price)					
Total	3.6%	5.0%	2.6%	3.6%	3.7%	2.9%
Systems with service contracts	7.2	8.5	5.8	6.4	6.5	6.4
All other systems	2.0	1.3	2.0	1.1	1.7	2.6

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological or environmental sciences). Instruments used only for instruction are excluded.

REFERENCE: Appendix Table 11.

SOURCE: National Science Foundation, SRS.

Figure 5. Percentage of academic research instruments with "state-of-the-art" capabilities, by equipment age*



* Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

Reference: Appendix Table 14
Source: National Science Foundation, SRS

appeared to be particularly commonplace for computers, where only about one-third of those in the 0-2 year age range were considered to be state-of-the-art (Table 9). At the other extreme, 65 percent of microscopes in the 0-2 year age range were judged to be state-of-the-art.

Other qualitative user assessments of the adequacy and condition of academic research equipment were also related to equipment age, though not as strongly as was state-of-the-art status (Table 9). Thus, 94 percent of systems in the 0-2 year age range were judged to have technical capabilities that were "adequate to meet research users' needs," as compared to 83 percent of those 6 or more years of age. Similarly, 76 percent of all research instruments in the 0-2 year age range were assessed as being in "excellent" working condition, as compared to a much lower 40 percent of those in the 6 year and over age range.

Controlling for age (i.e., within age categories), computers were judged adequate to meet research users' needs less often than other kinds of equipment, and microscopes were judged to be in excellent working condition more often than other kinds of equipment. Spectrometers had the lowest overall percentage judged to be in excellent working condition, but this appeared to reflect the somewhat advanced age distribution of this type of equipment, rather than any particular reliability or maintenence problems.

Table 9. Rated condition and adequacy of academic research equipment, by age and major types of equipment*

System rating** and age group	Major type of equipment					
	Total	Computers	Spectrometers	Microscopes	Bioanalysis	Other
	(Percent of systems)					
System has "state-of-the-art" capabilities						
Total	35%	23%	31%	37%	36%	43%
0-2 years	51	32	57	65	59	58
3-5 years	34	13	38	47	40	44
6+ years	15	9	11	15	11	24
System's technical capabilities (resolution, speed, etc.) are "adequate to meet research user's needs"						
Total	89	80	89	89	93	91
0-2 years	94	88	97	93	98	95
3-5 years	89	72	93	97	96	94
6+ years	83	69	81	82	87	84
System's general working condition is "excellent"						
Total	60	61	55	72	61	60
0-2 years	76	72	79	87	77	77
3-5 years	62	54	63	78	68	59
6+ years	40	41	35	60	38	40

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Ratings were made by the principal investigator with primary responsibility for the instruments.

REFERENCE: Appendix Tables 12-14.

SOURCE: National Science Foundation, SRS.

APPENDIX A

LIST OF SAMPLED INSTITUTIONS

Sampled Institutions

Nonmedical Colleges and Universities

Brown University
California Institute of Technology
Colorado State University
Cornell University
Duke University
Georgia Institute of Technology
Harvard University
Johns Hopkins University
Louisiana State University
Massachusetts Institute of Technology
Michigan State University
Mississippi State University
New Mexico Institute of Mining and Technology
North Carolina State University
Northeastern University
Northwestern University
Ohio State University
Oklahoma State University
Oregon State University
Pennsylvania State University
Princeton University
Purdue University
Rockefeller University
Stanford University
Stevens Institute of Technology
Temple University
Texas A&M University
Texas Tech University
University of Arizona
University of California at Berkeley
University of California at Davis
University of California at Los Angeles
University of California at San Diego
University of Central Florida
University of Colorado (Boulder and Denver)
University of Connecticut
University of Dayton
University of Denver
University of Illinois at Urbana/Champaign
University of Iowa
University of Kansas
University of Maryland at College Park
University of Michigan
University of Minnesota
University of Nebraska at Lincoln
University of North Dakota
University of Oklahoma
University of Pennsylvania
University of South Alabama
University of Texas at Austin
University of Washington
University of Wisconsin at Madison
Virginia Polytechnic Institute
Washington State University
Yale University

Medical Schools

Albert Einstein College of Medicine
Boston University Medical Campus
Duke University Medical Center
Johns Hopkins University School of Medicine
Mayo Medical School
Medical College of Ohio at Toledo
Northwestern University Medical School
Ohio State University College of Medicine
Temple University School of Medicine
University of California at Los Angeles School of Medicine
University of California at San Diego School of Medicine
University of California at San Francisco School of Medicine
University of Chicago Pritzker School of Medicine
University of Cincinnati College of Medicine
University of Colorado School of Medicine
University of Kansas Medical Center
University of Minnesota School of Medicine
University of Nebraska Medical Center
University of North Carolina School of Medicine
University of Pennsylvania School of Medicine
University of Texas Health Sciences Center at San Antonio
University of Texas Southwestern Medical Center
University of Washington School of Medicine
Yale University School of Medicine

APPENDIX B

INSTRUMENT DATA SHEET

OMB Number: 3145-0067
Expiration Date: 12/31/90

INSTRUMENT DATA SHEET

The National Science Foundation's Third
National Survey of Academic Research Instruments and Instrumentation Needs
Phase I, 1989

Conducted by Westat, Inc., 1650 Research Blvd., Rockville, MD 20850

This data sheet is part of a major national assessment of the amount, condition, and adequacy of academic research equipment in the $10,000 and above range. The data sheet concerns a particular item of equipment sampled from inventory records provided by your institution. The sampled item is described below.

We ask that the requested information be obtained from the principal investigator or other person(s) knowledgeable about the history and current status of this equipment item. Where exact cost (or other data) are not available, estimates are acceptable. Your estimates will be better than ours.

If you receive data sheets for two or more equipment items that are all components of a single instrument system, fill in only one data sheet - the one for the most costly component of the system. Use that data sheet to describe the entire system. Data sheets for the other components may be left blank except for entering the cross-reference notation "see Data Sheet number..." in the comments section at the end of the data sheet (item 16).

This study is authorized by law (P.L. 96-44). While you are not required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate, and timely. Information gathered in this survey will be used only for developing statistical summaries. Individual persons will not be identified in published summaries of the data.

Your cooperation in returning the data sheet promptly is very important. Please direct any questions about this form to your university study coordinator or to Ms. Cindy Gray at Westat (1-800-937-8281).

DEFINITION OF KEY TERMS

Purchase Month and Year (see label below). The year (and month, if known) when this instrument or its principal components were originally purchased from the manufacturer.

Purchase Price (initial value) (see label below). The original price paid for the instrument (or its components, if built locally) at the time of original purchase from the manufacturer. Do not add in the price of separately purchased accessories that are reported in Questions 1d-1f. Please estimate if original records are not available.

Dedicated Accessories (see Questions 1d-1f). Separately acquired "add-ons" to or components of the instrumentation system of which the instrument described below is the principal element. This includes accessories that are presently dedicated solely for use with the referenced instrument but are not included in its purchase price (in the label below).

NOTE: FOR SIMPLICITY, THIS DATA SHEET REFERS TO THE EQUIPMENT ITEM LISTED ON PAGE 1 AS AN "INSTRUMENT"

1. Additional identifying information about this instrument:

a. Instrument's status in 1988: (CIRCLE ONE)

Used in scientific research or instruction (CONTINUE TO QUESTION 1b) 1

Not yet in service – under development or construction (SKIP TO QUESTION 16) 2

No longer exists (cannibalized, junked, traded-in, or otherwise disposed of) (SKIP TO QUESTION 16) 3

Inactive or inoperable throughout 1988 (SKIP TO QUESTION 16).......... 4

Used only for purposes other than research or instruction (e.g., office or machine shop equipment (SKIP TO QUESTION 16) 5

Other (Specify) ____________ 6

b. Please give a brief description of the type of instrument or system this is (for example, HPLC/mass spectrometer with data acquisition add-on):

____

____

____

c. Is this instrument: (CIRCLE ONE)

A stand-alone instrument or system.......... 1

A component in a larger instrument system, of which it is the principal (most costly) component.......... 2

A component in a larger instrument system, of which it is not the principal (most costly) component.......... 3

Other (Specify)____________ 4

d. Does this instrument have any separately purchased "dedicated accessories" that are not included in the instrument "Purchase Price" (from label, page 1)? (SEE PAGE 1, DEFINITION OF KEY TERMS)

Yes (CONTINUE TO 1e AND 1f) 1

No (SKIP TO QUESTION 2) 2

e. Estimated aggregate purchase price of all dedicated accessories not included in the instrument "Purchase Price" on page 1:

$ ______________________

f. Please describe and estimate the purchase price of this instrument's main (most costly) accessories. (LIST UP TO FOUR MAIN ACCESSORIES)

	Description of Accessories	Purchase price
(1)	____________ ____________ ____________	$________
(2)	____________ ____________ ____________	$________
(3)	____________ ____________ ____________	$________
(4)	____________ ____________ ____________	$________

2. What was the principal broad field of research or instruction in which this instrument was used in 1988 (for example, chemistry, physics, astronomy, electrical engineering, computer science)?

____

3. How was this instrument acquired at this institution? (CIRCLE ONE)

Purchased new	1
Purchased used	2
Locally built (at or for this institution)	3
Transferred from another institution, e.g., by incoming faculty member	4
Government surplus	5
Gift/donation - new	6
Gift/donation - used	7
Other (Specify) ______________	8

4. Source(s) of funds for acquisition of this instrument, including dedicated accessories: (SPECIFY APPROXIMATE PERCENTAGE CONTRIBUTION FROM EACH APPLICABLE SOURCE)

FUNDING SOURCE	PERCENT
Federal Sources:	
NSF (National Science Foundation)	______
NIH (National Institutes of Health)	______
DOD (Department of Defense)	______
DOE (Department of Energy)	______
NASA (National Aeronautics & Space Admin.)	______
Other Federal sources (Specify)	______
______________________	
Non-Federal Sources:	
Institution or department funds	______
State grant or appropriation	______
Private, nonprofit foundation	______
Business or industry	______
Other (Specify)	______
______________________	
Total	100%

5. Instrument's location during 1988: (CIRCLE ONE)

National, regional, or interuniversity research lab	1
Nondepartmental research facility	2
Department-managed common lab or instrumentation facility	3
Within-department research lab of principal investigator	4
Within department teaching lab	5
Other (Specify) ______________	6

6. Expenditures for maintenance/repair (not for operation) of this instrument and its accessories in 1988 (for multi-year service contracts, warranties, etc., prorate to indicate cost of coverage in 1988)

$ ______________________

7. Provision for maintenance/repair of this instrument in 1988: (CIRCLE ONE ON EACH LINE)

	Yes	No
a. Warranty	1	2
b. Service contract	1	2
c. Field service, as needed	1	2
d. Institution-employed maintenance/repair staff	1	2
e. Research personnel (faculty, students, post-docs)	1	2
f. Other (Specify) ______________	1	2

8. Adequacy of the maintenance/repair this instrument received in 1988: (CIRCLE ONE)

Not applicable: no servicing was needed	1
Excellent	2
Adequate	3
Inadequate (How?) ______________	4

9. Instrument's general working condition in 1988: (CIRCLE ONE)

Excellent	1
Average	2
Poor (e.g., unreliable, frequent breakdowns)	3
Inoperable the entire year	4

10. Instrument's technical capabilities (resolution, speed, etc.): (CIRCLE ONE)

Adequate to meet research users' needs	1
Inadequate for research (Please explain)	2

____

____

11. Instrument's research vs. instructional use in 1988: (CIRCLE ONE)

Used entirely for research 1
Used predominantly for research, with some instructional use 2
Used predominantly for instruction, with some research use 3
Used entirely for instruction (SKIP TO QUESTION 16) 4
Other (Specify)________________________ 5

12. Research status of this instrument in 1988: (CIRCLE ONE)

State-of-the-art: the most highly developed and scientifically sophisticated instrument of its kind 1

Not state-of-the-art, but more advanced instruments are available to its users when needed 2

Not state-of-the-art; more advanced instruments are not available to its users 3

13. Number of research investigators who made use of this instrument for research purposes during 1988: (ESTIMATE APPROXIMATE NUMBER IN EACH CATEGORY)

	NUMBER
a. Faculty (and equivalents), this department/facility	______
b. Graduate students and post-doctorates, this department/facility	______
c. Researchers from other departments/facilities of this university	______
d. Researchers outside this university ...	______
e. Other (Specify) _______________ ..... ______________________________	______
f. Total number of research users	______

14. Instrument's estimated remaining useful research life: (ESTIMATE THE NUMBER OF ADDITIONAL YEARS OF USEFUL RESEARCH SERVICE)

____
YEARS

15. When it is retired from research use, what do you expect will be done with this instrument? (CIRCLE MOST LIKELY POSSIBILITY)

Used for instructional purposes 1
Used as a trade-in 2
Other (e.g., cannibalized, discarded) 3

16. **Comments.** Please note in the space below any additional information needed to clarify the nature, function and quality of this instrument.

____

____

____

____

Person who prepared this submission: (PLEASE PRINT)

Name: ______________________________________

Title: ______________________________________

Telephone No. (________)____________________________

Estimated time required to complete this form:

________ ________
Hours Minutes

OMB Number: 3145-0067
Expiration Date: 12/31/90

INSTRUMENT DATA SHEET

The Third National Science Foundation and National Institutes of Health
National Survey of Academic Research Instruments and Instrumentation Needs
Phase 2, Fall 1989

Conducted by Westat, Inc., 1650 Research Blvd., Rockville, MD 20850

INTRODUCTION

This data sheet is part of a major periodic survey of trends in the amount, condition, and adequacy of academic research and instructional equipment. The survey is conducted every three years jointly by the National Science Foundation and the National Institutes of Health to assess emerging needs and evaluate current instrumentation funding programs and policies. Several Federal instrumentation grant programs have already been established or revised based on data from earlier studies in this series. An executive summary of the results of the previous survey is available from your department or facility chairman. Additional reports are available through NSF, NIH, or Westat, the survey contractor.

This study is authorized by law (P.L. 96-44). While you are not required to respond, your cooperation is needed to make the results comprehensive, accurate, and timely. Survey responses will be used only for developing statistical summaries; individual persons will not be identified in published reports of the data. If you have any questions about this study, or if you wish to request additional copies of study reports, please call Cindy Gray at Westat (1-800-937-8281).

INSTRUCTIONS

1. This data sheet concerns a particular item of equipment sampled from inventory records provided by your institution. The sampled item is described on the label below. Please review the label and make any necessary corrections to the information. The purchase date and price should reflect the date and price of this instrument (or its principal components, if built at the school) at the time of original purchase from the manufacturer.

2. We ask that the requested information be obtained from the principal investigator or other person(s) knowledgeable about the history and current status of this equipment item. Where exact data are not available, estimates are acceptable. Your estimates will be better than ours.

3. If you receive data sheets for two or more equipment items that are all components of a single instrument system, fill in only one data sheet – the one for the most costly component of the system. Use that data sheet to describe the entire system (listing the other components as accessories in question 1f). Data sheets for the other components may be returned blank, except for entering the notation "See data sheet number..." in question 16.

4. Please return the completed data sheet(s) to the department or facility representative who distributed them to you by the deadline date set by that person. Your cooperation in returning the data sheet(s) promptly is very important.

NOTE: FOR SIMPLICITY, THIS DATA SHEET REFERS TO THE EQUIPMENT ITEM LISTED ON PAGE 1 AS AN "INSTRUMENT"

1. Additional identifying information about this instrument:

a. Instrument's status in 1989: (CIRCLE ONE)

Used in scientific research or instruction (CONTINUE TO QUESTION 1b) 1

Not yet in service -- under development or construction (SKIP TO QUESTION 16) 2

No longer exists (cannibalized, junked, traded-in, or otherwise disposed of) (SKIP TO QUESTION 16) 3

Inactive or inoperable throughout 1989 (SKIP TO QUESTION 16)............. 4

Used only for purposes other than research or instruction (e.g., office or machine shop equipment (SKIP TO QUESTION 16) 5

Other (Specify) ____________________ 6

b. Please give a brief description of the type of instrument or system this is (for example, HPLC/mass spectrometer with data acquisition add-on):

____

____

____

c. Is this instrument: (CIRCLE ONE)

A stand-alone instrument or system.. 1

A component in a larger instrument system, of which it is the principal (most costly) component........................ 2

A component in a larger instrument system, of which it is not the principal (most costly) component....................... 3

Other (Specify)____________________ 4

d. Does this instrument have any separately purchased dedicated accessories that are not included in the instrument purchase price (from label, page 1)? (SEE PAGE 1, INSTRUCTIONS 1 AND 3)

Yes (CONTINUE TO 1e AND 1f) 1
No (SKIP TO QUESTION 2) 2

e. Estimated aggregate purchase price of all dedicated accessories not included in the instrument "purchase price" on page 1:

$ ______________________________

f. Please describe and estimate the purchase price of this instrument's main (most costly) accessories. (LIST UP TO FOUR MAIN ACCESSORIES)

	Description of Accessories	Purchase price
(1)	____________________ ____________________ ____________________	$__________
(2)	____________________ ____________________ ____________________	$__________
(3)	____________________ ____________________ ____________________	$__________
(4)	____________________ ____________________ ____________________	$__________

2. What was the principal broad field of research or instruction in which this instrument was used in 1989 (for example, physiology, biochemistry, oceanography, geology, agronomy)?

____

3. How was this instrument acquired at this institution? (CIRCLE ONE)

Purchased new	1
Purchased used	2
Fabricated (at or for this institution)	3
Transferred from another institution, e.g., by incoming faculty member	4
Government surplus	5
Gift/donation - new	6
Gift/donation - used	7
Other (Specify) ______________________	8

4. Source(s) of funds for acquisition of this instrument, including dedicated accessories: (SPECIFY APPROXIMATE PERCENTAGE CONTRIBUTION FROM EACH APPLICABLE SOURCE)

FUNDING SOURCE	PERCENT
Federal Sources:	
NSF (National Science Foundation)	______
NIH (National Institutes of Health)	______
DOD (Department of Defense)	______
DOE (Department of Energy)	______
USDA (Department of Agriculture)	______
Other Federal sources (Specify) ______________________	______
Non-Federal Sources:	
Institution or department funds	______
State grant or appropriation	______
Private, nonprofit foundation	______
Business or industry	______
Other (Specify) ______________________	______
Total	100%

5. Instrument's location during 1989: (CIRCLE ONE)

National, regional, or interuniversity research lab	1
Nondepartmental research facility	2
Department-managed common lab or instrumentation facility	3
Within-department research lab of principal investigator	4
Within department teaching lab	5
Other (Specify) ______________________	6

6. Expenditures for maintenance/repair (not for operation) of this instrument and its accessories in 1989 (for multi-year service contracts, warranties, etc., prorate to indicate cost of coverage in 1989)

$ ______________________

7. Provision for maintenance/repair of this instrument in 1989: (CIRCLE ONE ON EACH LINE)

	Yes	No
a. Warranty	1	2
b. Service contract	1	2
c. Field service, as needed	1	2
d. Institution-employed maintenance/repair staff	1	2
e. Research personnel (faculty, students, post-docs)	1	2
f. Other (Specify) ______________________	1	2

8. Adequacy of the maintenance/repair this instrument received in 1989: (CIRCLE ONE)

Not applicable: no servicing was needed	1
Excellent	2
Adequate	3
Inadequate (How?) ______________________	4

9. Instrument's general working condition in 1989: (CIRCLE ONE)

Excellent	1
Average	2
Poor (e.g., unreliable, frequent breakdowns)	3
Inoperable the entire year	4

10. Instrument's technical capabilities (resolution, speed, etc.): (CIRCLE ONE)

Adequate to meet research users' needs	1
Inadequate for research (Please explain)	2

____

____

11. Instrument's research vs. instructional use in 1989: (CIRCLE ONE)

Used entirely for research	1
Used predominantly for research, with some instructional use	2
Used predominantly for instruction, with some research use	3
Used entirely for instruction (SKIP TO QUESTION 16)	4
Other (Specify)______________________	5

12. Research status of this instrument in 1989: (CIRCLE ONE)

State-of-the-art: the most highly developed and scientifically sophisticated instrument of its kind	1
Not state-of-the-art, but more advanced instruments are available to its users when needed	2
Not state-of-the-art; more advanced instruments are not available to its users	3

13. Number of research investigators who made use of this instrument for research purposes during 1989: (ESTIMATE APPROXIMATE NUMBER IN EACH CATEGORY)

	NUMBER
a. Faculty (and equivalents), this department/facility	______
b. Graduate students and post-doctorates, this department/facility	______
c. Researchers from other departments/facilities of this university	______
d. Researchers outside this university	______
e. Other (Specify) ______________ ______________	______
f. Total number of research users	______

14. Instrument's estimated remaining useful research life: (ESTIMATE THE NUMBER OF ADDITIONAL YEARS OF USEFUL RESEARCH SERVICE)

________ YEARS

15. When it is retired from research use, what do you expect will be done with this instrument? (CIRCLE MOST LIKELY POSSIBILITY)

Used for instructional purposes	1
Used as a trade-in	2
Other (e.g., cannibalized, discarded)	3

16. **Comments.** Please note in the space below any additional information needed to clarify the nature, function and quality of this instrument.

____

____

____

____

Person who prepared this submission: (PLEASE PRINT)

Name: ________________________________

Title: ________________________________

Telephone No. (______) ________________________

Estimated time required to complete this form:

______ Hours ______ Minutes

APPENDIX C

DETAILED ANALYSIS TABLES

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Table 1. Total amount and system purchase price range of academic research/instructional equipment, by type of equipment, 1988-89*

Type of equipment	Number of systems	System purchase price			
		Aggregate	25th percentile)	Median (50th percentile	75th percentile
		(Dollars in thousands)			
Total	81,753	$3,253,840	$14.4	$21.0	$36.7
Computers and data handling equipment	18,363	813,821	14.5	22.5	43.7
Graphics/CAD/image analysis equipment	2,659	104,929	13.7	26.0	48.2
Other systems ≥ $200,000	506	179,978	239.7	310.1	427.2
Other systems/components < $200,000	15,198	528,915	14.5	21.1	38.5
Spectroscopy and light measurement equipment	12,762	707,753	14.9	22.0	50.5
Electron/auger/ion scattering	963	96,487	17.1	35.0	127.7
Infrared/FTIR/laser Raman	1,162	64,235	18.0	31.4	74.9
Mass/GC-MS	922	122,283	48.7	73.0	178.5
NMR/magnets	1,118	163,184	22.4	54.8	232.0
Ultraviolet/UV-VIS	2,920	61,746	13.4	17.6	23.6
X-ray (diffractometers, etc.)	1,232	91,509	26.9	50.5	101.5
Other spectroscopy equipment	4,446	108,309	13.5	17.8	26.0
Microscopes and accessories	5,490	254,875	14.8	24.3	42.1
Electron microscopes	1,238	148,090	43.1	86.2	155.6
Other microscopy equipment	4,251	106,784	13.8	19.6	30.0
Bioanalytical instruments	20,107	572,380	14.3	20.0	28.4
Cell sorters/counters, cytometers	330	23,860	11.3	14.0	85.1
Centrifuges and accessories	6,783	196,548	15.9	23.7	36.0
Chromatographs and elemental analyzers (except CG-MS)	5,353	116,831	13.5	18.1	25.3
DNA/protein synthesizers/ sequencers/analyzers	1,439	101,060	18.9	34.9	89.2
Growth/environmental chambers	1,893	48,113	13.9	16.9	24.3
Scintillation/gamma radiation/ counters/detectors	4,309	85,970	13.6	18.8	22.1
Other	25,032	905,011	13.7	20.7	35.0
Electronics equipment (cameras, recorders, etc.)	5,124	131,091	12.3	17.4	27.7
Temperature/pressure control/ measurement equipment	3,969	95,274	11.8	16.0	24.0
Lasers and optical/motion analysis equipment	4,318	200,151	18.8	30.7	52.0
Major prototype instrument systems**	633	152,052	13[illegible].2	160.6	263.1
Other systems <$100,000	10,987	326,443	14.1	20.5	33.4

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research and/or instruction in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences).

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

SOURCE: National Science Foundation, SRS

Table 2. Aggregate purchase price of academic research/instructional equipment by science/engineering field and type of equipment, 1988-89*

Type of equipment	Total	Science/engineering field							
				Biological sciences					
		Engineering	Agricultural sciences	Medical schools	Other settings	Chemistry	Computer science	Environmental sciences	Physics/astronomy
					(Dollars in million)				
Total	$3,253.8	$884.5	$93.6	$515.7	$415.4	$557.8	$175.4	$246.9	$364.4
Computers and data handling equipment	813.8	291.8	8.8	49.2	40.7	55.9	171.7	82.8	112.9
Graphics/CAD/image analysis equipment	104.9	47.3	1.9	12.8	13.3	3.7	4.8	13.1	8.1
Other systems ≥ $200,000	180.0	64.7	1.1	8.9	2.6	12.7	35.3	29.1	25.7
Other systems/components < $200,000	528.9	179.8	5.9	27.4	24.8	39.5	131.6	40.6	79.2
Spectroscopy and light measurement equipment	707.8	59.1	20.0	85.4	72.7	342.1	0.2	68.8	59.4
Electron/auger/ion scattering	96.5	14.9	0.3	6.6	2.0	45.0	.	12.8	15.0
Infrared/FTIR/laser Raman	64.2	10.0	1.6	.	1.1	41.4	.	0.7	9.5
Mass/GC-MS	122.3	4.5	2.1	9.8	11.6	64.4	.	26.2	3.8
NMR/magnets	163.2	1.8	.	13.3	9.9	123.4	.	1.1	13.7
Ultraviolet/UV-VIS	61.7	1.5	3.8	18.1	21.3	15.2	.	0.3	1.6
X-ray (diffractometers, etc.)	91.5	17.5	1.5	7.4	8.6	34.8	.	16.4	5.2
Other spectroscopy equipment	108.3	8.9	10.7	30.3	18.1	18.0	0.2	11.4	10.6
Microscopes and accessories	254.9	53.4	8.0	87.3	78.7	6.2	.	17.6	3.7
Electron microscopes	148.1	45.9	3.0	42.9	39.9	4.0	.	10.2	2.2
Other microscopy equipment	106.8	7.5	5.0	44.5	38.8	2.2	.	7.4	1.5
Bioanalytical instruments	572.4	33.2	40.2	252.9	187.1	38.1	.	7.4	13.5
Cell sorters/counters, cytometers	23.9	0.3	0.5	12.8	10.1	.	.	0.2	.
Centrifuges and accessories	196.5	4.0	12.3	99.5	77.1	3.1	.	0.5	.
Chromatographs and elemental analyzers (except CG-MS)	116.8	18.6	10.5	28.0	31.3	23.4	.	3.9	1.1
DNA/protein synthesizers/sequencers/analyzers	101.1	0.4	2.5	59.6	34.1	3.4	.	0.2	0.8
Growth/environmental chambers	48.1	8.4	10.2	6.3	10.9	6.2	.	0.4	5.7
Scintillation/gamma radiation/counters/detectors	86.0	1.3	4.3	46.6	23.7	1.9	.	2.1	5.9
Other	905.0	447.1	16.6	40.9	36.2	115.5	3.5	70.4	174.9
Electronics equipment (cameras, recorders, etc.)	131.1	57.6	1.0	10.1	6.3	16.8	.	10.0	29.4
Temperature/pressure control/measurement equipment	95.3	28.6	3.3	16.4	13.7	9.8	.	3.6	19.8
Lasers and optical/motion analysis equipment	200.2	64.8	0.2	1.6	3.4	65.4	.	12.8	52.0
Major prototype instrument systems**	152.1	88.7	1.4	1.6	1.2	6.2	1.1	16.4	35.4
Other systems <$100,000	326.4	207.4	10.7	11.1	11.7	17.4	2.3	27.6	38.2

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research and/or instiuction in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological or environmental sciences).

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 2A. Distribution of academic research/instructional equipment by science/engineering field and type of equipment, 1988-89*

Type of equipment	Total	Science/engineering field							
		Engineering	Agricultural sciences	Biological sciences		Chemistry	Computer science	Environmental sciences	Physics/astronomy
				Medical schools	Other settings				
		(Percent of aggregate purchase price)							
Total	100%	27%	3%	16%	13%	17%	5%	8%	11%
Computers and data handling equipment	100	36	1	6	5	7	21	10	14
Graphics/CAD/image analysis equipment	100	45	2	12	13	4	5	12	8
Other systems ≥ $200,000	100	36	1	5	1	7	20	16	14
Other systems/components < $200,000	100	34	1	5	5	7	25	8	15
Spectroscopy and light measurement equipment	100	8	3	12	10	48	0	10	8
Electron/auger/ion scattering	100	15	0	7	2	47	.	13	16
Infrared/FTIR/laser Raman	100	16	2	.	2	64	.	1	15
Mass/GC-MS	100	4	2	8	9	53	.	21	3
NMR/magnets	100	1	.	8	6	76	.	1	8
Ultraviolet/UV-VIS	100	2	6	29	35	25	.	0	3
X-ray (diffractometers, etc.)	100	19	2	8	9	38	.	18	6
Other spectroscopy equipment	100	8	10	28	17	17	0	11	10
Microscopes and accessories	100	21	3	34	31	2	.	7	1
Electron microscopes	100	31	2	29	27	3	.	7	1
Other microscopy equipment	100	7	5	42	36	2	.	7	1
Bioanalytical instruments	100	6	7	44	33	7	.	1	2
Cell sorters/counters, cytometers	100	1	2	54	42	.	.	1	.
Centrifuges and accessories	100	2	6	51	39	2	.	0	.
Chromatographs and elemental analyzers (except CG-MS)	100	16	9	24	27	20	.	3	1
DNA/protein synthesizers/sequencers/analyzers	100	0	2	59	34	3	.	0	1
Growth/environmental chambers	100	18	21	13	23	13	.	1	12
Scintillation/gamma radiation/counters/detectors	100	2	5	54	28	2	.	2	7
Other	100	49	2	5	4	13	0	8	19
Electronics equipment (cameras, recorders, etc.)	100	44	1	8	5	13	.	8	22
Temperature/pressure control/measurement equipment	100	30	4	17	14	10	.	4	21
Lasers and optical/motion analysis equipment	100	32	0	1	2	33	.	6	26
Major prototype instrument systems**	100	58	1	1	1	4	1	11	23
Other systems <$100,000	100	64	3	3	4	5	1	8	12

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research and/or instruction in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological or environmental sciences).

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 3. Usage of academic research/instructional equipment, by type of equipment, 1989*

Type of equipment	Usage in 1989					
	Total	Research only	Both research and instruction		Instruction only	Other
			Predominately research	Predominately instruction		
	(Percent of systems)					
Total	100%	62%	28%	5%	3%	0%
Computers and data handling equipment	100	54	30	10	5	1
Graphics/CAD/image analysis equipment	100	48	33	14	4	1
Other systems ≥ $200,000	100	37	47	13	3	1
Other systems/components < $200,000	100	56	28	9	5	1
Spectroscopy and light measurement equipment	100	65	27	5	2	0
Electron/auger/ion scattering	100	71	23	6	.	.
Infrared/FTIR/laser Raman	100	56	33	9	2	.
Mass/GC-MS	100	68	31	.	.	1
NMR/magnets	100	50	38	7	6	.
Ultraviolet/UV-VIS	100	74	23	2	1	.
X-ray (diffractometers, etc.)	100	52	37	10	1	.
Other spectroscopy equipment	100	68	24	6	3	0
Microscopes and accessories	100	54	41	5	1	0
Electron microscopes	100	33	55	10	1	1
Other microscopy equipment	100	60	37	3	0	.
Bioanalytical instruments	100	71	27	1	1	0
Cell sorters/counters, cytometers	100	72	27	2	.	.
Centrifuges and accessories	100	68	30	1	0	0
Chromatographs and elemental analyzers (except CG-MS)	100	73	25	1	1	.
DNA/protein synthesizers/ sequencers/analyzers	100	85	14	.	.	1
Growth/environmental chambers	100	63	33	3	1	.
Scintillation/gamma radiation/ counters/detectors	100	73	26	0	0	0
Other	100	61	27	6	6	0
Electronics equipment (cameras, recorders, etc.)	100	71	21	4	4	0
Temperature/pressure control/ measurement equipment	100	68	24	3	3	2
Lasers and optical/motion analysis equipment	100	82	14	3	1	.
Major prototype instrument systems**	100	51	34	8	7	.
Other	100	48	35	8	9	0

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research and/or instruction in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological or environmental sciences).

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 4. Mean number of research users of academic research equipment, by type of equipment, 1989*

Type of equipment	Mean number of research users per system in 1989			
	Total	Faculty of host department/ facility	Graduate students and postdoctorates, host department/facility	All other users
Total	17	4	10	3
Computers and data handling equipment	31	6	20	4
Graphics/CAD/image analysis equipment	14	3	9	2
Other systems ≥ $200,000	69	14	47	9
Other systems/components < $200,000	32	7	21	4
Spectroscopy and light measurement equipment	15	3	10	3
Electron/auger/ion scattering	11	3	5	3
Infrared/FTIR/laser Raman	20	4	14	2
Mass/GC-MS	30	5	19	6
NMR/magnets	33	6	22	6
Ultraviolet/UV-VIS	12	3	7	1
X-ray (diffractometers, etc.)	15	3	9	3
Other spectroscopy equipment	10	2	6	2
Microscopes and accessories	12	3	6	3
Electron microscopes	20	5	9	6
Other microscopy equipment	10	3	5	2
Bioanalytical instruments	14	4	8	3
Cell sorters/counters, cytometers	10	4	3	3
Centrifuges and accessories	17	4	11	2
Chromatographs and elemental analyzers (except CG-MS)	7	2	4	1
DNA/protein synthesizers/ sequencers/analyzers	23	5	5	13
Growth/environmental chambers	7	2	4	1
Scintillation/gamma radiation/ counters/detectors	19	5	11	4
Other	11	3	5	2
Electronics equipment (cameras, recorders, etc.)	10	3	4	3
Temperature/pressure control/ measurement equipment	16	5	9	2
Lasers and optical/motion analysis equipment	6	2	3	1
Major prototype instrument systems**	18	4	9	6
Other	10	3	5	2

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 5. Expected disposition of academic research equipment when no longer useful for research, by type of equipment, 1989*

Type of equipment	Expected disposition when no longer useful for research			
	Total	Used for instruction	Traded-in	Other/unknown
	(Percent of systems)			
Total	100%	19%	32%	49%
Computers and data handling equipment	100	18	32	50
Graphics/CAD/image analysis equipment	100	22	24	54
Other systems ≥ $200,000	100	7	53	40
Other systems/components < $200,000	100	18	32	50
Spectroscopy and light measurement equipment	100	22	25	53
Electron/auger/ion scattering	100	16	21	63
Infrared/FTIR/laser Raman	100	43	32	26
Mass/GC-MS	100	24	21	55
NMR/magnets	100	36	17	47
Ultraviolet/UV-VIS	100	18	31	50
X-ray (diffractometers, etc.)	100	16	23	61
Other spectroscopy equipment	100	19	23	58
Microscopes and accessories	100	30	47	23
Electron microscopes	100	22	56	22
Other microscopy equipment	100	32	44	24
Bioanalytical instruments	100	11	44	45
Cell sorters/counters, cytometers	100	10	24	67
Centrifuges and accessories	100	5	62	33
Chromatographs and elemental analyzers (except CG-MS)	100	19	27	55
DNA/protein synthesizers/sequencers/analyzers	100	16	34	49
Growth/environmental chambers	100	21	9	70
Scintillation/gamma radiation/counters/detectors	100	7	57	36
Other	100	22	23	55
Electronics equipment (cameras, recorders, etc.)	100	34	16	50
Temperature/pressure control/measurement equipment	100	8	23	69
Lasers and optical/motion analysis equipment	100	18	28	54
Major prototype instrument systems**	100	21	18	61
Other	100	24	24	52

*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological or environmental sciences). Instruments used only for instruction are excluded.

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 6. Age of academic research equipment, by type of equipment, 1988-89*

Type of equipment	Median age	Age range				
		Total	0-2 years	3-5 years	6-8 years	9+ years
		(Percent of systems)				
Total	3	100	38	31	13	18
Computers and data handling equipment	3	100	52	35	7	5
Graphics/CAD/image analysis equipment	3	100	50	30	10	11
Other systems ≥ $200,000	3	100	48	32	16	4
Other systems/components < $200,000	2	100	53	36	6	4
Spectroscopy and light measurement equipment	5	100	28	28	18	26
Electron/auger/ion scattering	6	100	30	20	22	28
Infrared/FTIR/Laser Raman	3	100	39	29	20	12
Mass/GC-MS	4	100	38	33	11	18
NMR/magnets	7	100	21	22	23	35
Ultraviolet/UV-VIS	5	100	27	32	17	25
X-ray (diffractometers, etc.)	5	100	36	19	15	30
Other spectroscopy equipment	6	100	21	31	20	28
Microscopes and accessories	6	100	27	27	18	28
Electron microscopes	9	100	17	18	14	51
Other microscopy equipment	5	100	30	30	19	22
Bioanalytical instruments	6	100	32	33	13	21
Cell sorters/counters, cytometers	5	100	23	44	31	3
Centrifuges and accessories	5	100	35	35	10	20
Chromatographs and elemental analyzers (except CG-MS)	5	100	36	34	17	13
DNA/protein synthesizers/sequencers/analyzers	4	100	46	41	5	8
Growth/environmental chambers	4	100	41	32	12	15
Scintillation/gamma radiation/counters/detectors	8	100	16	25	15	44
Other	3	100	40	28	14	18
Electronics equipment (cameras, recorders, etc.)	3	100	48	26	14	12
Temperature/pressure control/measurement equipment	4	100	40	24	12	24
Lasers and optical/motion analysis equipment	3	100	39	33	18	10
Major prototype instrument systems**	4	100	34	22	12	32
Other	4	100	37	29	12	22

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 7. Remaining useful research life academic research equipment, by type of equipment, 1988-89*

Type of equipment	Expected number of years of remaining useful research life					
	Median	Distribution				
		Total	0-2 years	3-5 years	6-8 years	9+ years
		(Percent of systems)				
Total	5	100	18	42	10	30
Computers and data handling equipment	3	100	40	46	5	9
Graphics/CAD/image analysis equipment	3	100	36	50	8	5
Other systems ≥ $200,000	2	100	58	34	2	6
Other systems/components < $200,000	3	100	40	45	5	9
Spectroscopy and light measurement equipment	5	100	14	45	11	29
Electron/auger/ion scattering	5	100	23	30	15	32
Infrared/FTIR/laser Raman	5	100	13	60	7	19
Mass/GC-MS	5	100	7	45	11	38
NMR/magnets	5	100	11	45	10	34
Ultraviolet/UV-VIS	5	100	11	58	16	15
X-ray (diffractometers, etc.)	6	100	15	33	7	44
Other spectroscopy equipment	5	100	16	40	11	33
Microscopes and accessories	10	100	8	29	7	57
Electron microscopes	5	100	19	40	11	30
Other microscopy equipment	10	100	4	25	6	64
Bioanalytical instruments	5	100	11	39	11	38
Cell sorters/counters, cytometers	5	100	3	51	3	43
Centrifuges and accessories	10	100	8	23	11	58
Chromatographs and elemental analyzers (except CG-MS)	5	100	12	52	13	23
DNA/protein synthesizers/ sequencers/analyzers	5	100	11	45	13	31
Growth/environmental chambers	8	100	5	32	14	50
Scintillation/gamma radiation/ counters/detectors	5	100	21	49	8	22
Other	5	100	11	44	11	35
Electronics equipment (cameras, recorders, etc.)	5	100	13	45	11	31
Temperature/pressure control/ measurement equipment	7	100	7	34	15	44
Lasers and optical/motion analysis equipment	5	100	17	51	10	23
Major prototype instrument systems**	8	100	10	32	10	48
Other	5	100	9	44	10	37

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 8. Expected total useful research life of academic research equipment, by type of equipment, 1988-89*

Type of equipment	Expected total number of years of useful research life**					
	Median	Distribution				
		Total	0-2 years	3-5 years	6-8 years	9+ years
		(Percent of systems)				
Total	11	100	2	14	22	63
Computers and data handling equipment	6	100	6	38	31	25
Graphics/CAD/image analysis equipment	6	100	4	34	35	27
Other systems ≥ $200,000	5	100	10	40	31	18
Other systems/components < $200,000	6	100	6	39	30	24
Spectroscopy and light measurement equipment	11	100	0	5	21	74
Electron/auger/ion scattering	11	100	.	7	16	77
Infrared/FTIR/laser Raman	9	100	.	15	33	53
Mass/GC-MS	12	100	1	4	20	76
NMR/magnets	13	100	.	2	14	83
Ultraviolet/UV-VIS	11	100	.	2	31	67
X-ray (diffractometers, etc.)	13	100	.	4	16	80
Other spectroscopy equipment	12	100	0	4	15	81
Microscopes and accessories	15	100	1	4	9	86
Electron microscopes	15	100	1	2	14	83
Other microscopy equipment	15	100	0	5	8	87
Bioanalytical instruments	12	100	0	5	17	77
Cell sorters/counters, cytometers	12	100	.	3	12	85
Centrifuges and accessories	14	100	1	4	8	88
Chromatographs and elemental analyzers (except CG-MS)	10	100	.	9	28	63
DNA/protein synthesizers/ sequencers/analyzers	9	100	0	15	31	54
Growth/environmental chambers	12	100	.	2	23	75
Scintillation/gamma radiation/ counters/detectors	12	100	.	1	10	88
Other	10	100	1	9	23	67
Electronics equipment (cameras, recorders, etc.)	10	100	1	16	23	60
Temperature/pressure control/ measurement equipment	12	100	1	4	15	80
Lasers and optical/motion analysis equipment	10	100	1	13	29	58
Major prototype instrument systems***	13	100	0	10	17	73
Other	11	100	1	6	23	70

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Total = instrument's current age plus user estimate of its remaining useful research life.

***Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 9. Estimated replacement cost of academic research instruments with expected remaining useful research lives of less than 3 years, by type of equipment, 1988-89*

Type of equipment	Number of systems to be retired in 0-2 years	Mean price per system	Estimated aggregate replacement cost**
		(Dollars in thousands)	
Total	13,517	$40	$540,680
Computers and data handling equipment	6,796	45	305,820
Graphics/CAD/image analysis equipment	892	40	35,680
Other systems ≥ $200,000	276	354	97,704
Other systems/components < $200,000	5,629	35	197,015
Spectroscopy and light measurement equipment	1,699	56	95,144
Electron/auger/ion scattering	218	100	21,800
Infrared/FTIR/laser Raman	151	56	8,456
Mass/GC-MS	62	133	8,246
NMR/magnets	116	153	17,748
Ultraviolet/UV-VIS	307	21	6,447
X-ray (diffractometers, etc.)	182	75	13,650
Other spectroscopy equipment	663	25	16,575
Microscopes and accessories	381	47	17,907
Electron microscopes	222	121	26,862
Other microscopy equipment	159	25	3,975
Bioanalytical instruments	2,174	28	60,872
Cell sorters/counters, cytometers	8	72	576
Centrifuges and accessories	494	29	14,326
Chromatographs and elemental analyzers (except CG-MS)	591	22	13,002
DNA/protein synthesizers/ sequencers/analyzers	157	70	10,990
Growth/environmental chambers	85	26	2,210
Scintillation/gamma radiation/ counters/detectors	840	20	16,800
Other	2,466	37	91,242
Electronics equipment (cameras, recorders, etc.)	600	26	15,600
Temperature/pressure control/ measurement equipment	234	24	5,616
Lasers and optical/motion analysis equipment	701	47	32,947
Major prototype instrument systems***	56	248	13,888
Other	875	30	26,250

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Estimated replacement cost = number of systems with expected remaining useful research lives of 0-2 years (see Table 7), times the mean purchase price of systems currently in research use (see Table 1).

***Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

SOURCE: National Science Foundation, SRS

Table 10. Provision for maintenance of academic research equipment, by type of equipment, 1988-89*

Type of equipment	Provision for maintenance/repair						
	Total	Warranty	Service contract	Field service as needed	Institution M/R staff	Research personnel	Other
				(Percent of systems)			
Total	100+%	18%	24%	44%	40%	47%	3%
Computers and data handling equipment	100+	20	38	42	43	33	3
Graphics/CAD/image analysis equipment	100+	17	26	48	48	38	1
Other systems ≥ $200,000	100+	21	76	44	40	21	2
Other systems/components < $200,000	100+	20	38	41	43	33	3
Spectroscopy and light measurement equipment	100+	14	11	46	48	57	2
Electron/auger/ion scattering	100+	13	7	36	45	76	.
Infrared/FTIR/laser Raman	100+	16	9	53	58	61	0
Mass/GC-MS	100+	14	15	39	61	79	2
NMR/magnets	100+	9	10	41	61	68	1
Ultraviolet/UV-VIS	100+	16	20	49	45	44	1
X-ray (diffractometers, etc.)	100+	11	14	50	57	70	3
Other spectroscopy equipment	100+	13	6	47	40	49	2
Microscopes and accessories	100+	19	19	58	26	50	3
Electron microscopes	100+	8	68	35	37	46	3
Other microscopy equipment	100+	23	5	65	23	52	3
Bioanalytical instruments	100+	17	39	43	28	39	3
Cell sorters/counters, cytometers	100+	40	17	28	32	56	0
Centrifuges and accessories	100+	18	61	41	20	23	0
Chromatographs and elemental analyzers (except CG-MS)	100+	16	16	47	35	71	2
DNA/protein synthesizers/sequencers/analyzers	100+	21	25	39	37	48	8
Growth/environmental chambers	100+	25	5	36	53	46	6
Scintillation/gamma radiation/counters/detectors	100+	11	52	45	18	18	4
Other	100+	19	8	42	48	59	3
Electronics equipment (cameras, recorders, etc.)	100+	21	10	43	50	50	4
Temperature/pressure control/measurement equipment	100+	21	18	37	43	53	1
Lasers and optical/motion analysis equipment	100+	24	7	41	29	71	3
Major prototype instrument systems***	100+	8	7	23	58	64	5
Other	100+	17	5	46	57	61	2

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**More than one provision may apply. Consequently, row percentages may sum to more than 100+.

***Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100+,000 not classified elsewhere.

SOURCE: National Science Foundation, SRS

Table 11. Annual maintenance/repair (M/R) expenditures for academic research equipment, by type of equipment, 1988-89*

Type of equipment	Mean M/R expenditures per system			M/R expenditures as a percentage of system purchase price		
	Total	Systems with service contracts	All other systems	Total	Systems with service contracts	All other systems
	(Dollars in thousands)			(Percent)		
Total	$1.4	$3.7	$0.7	3.6%	7.2%	2.0%
Computers and data handling equipment	2.2	5.2	0.5	5.0	8.5	1.3
Graphics/CAD/image analysis equipment	1.4	4.1	0.4	3.4	7.3	1.2
Other systems ≥ $200,000	21.1	26.4	4.8	6.0	7.7	1.2
Other systems/components < $200,000	1.7	3.9	0.4	4.9	9.1	1.3
Spectroscopy and light measurement equipment	1.5	4.9	1.0	2.6	5.8	2.0
Electron/auger/ion scattering	2.4	15.2	1.5	2.4	3.9	1.9
Infrared/FTIR/laser Raman	1.8	5.2	1.5	3.3	8.4	2.7
Mass/GC-MS	4.2	9.6	3.2	3.1	7.8	2.4
NMR/magnets	2.8	11.1	1.8	1.8	3.9	1.3
Ultraviolet/UV-VIS	0.6	1.7	0.3	2.7	9.4	1.4
X-ray (diffractometers, etc.)	2.2	6.7	1.5	2.9	4.9	2.3
Other spectroscopy equipment	0.7	3.3	0.5	2.7	9.8	2.0
Microscopes and accessories	1.7	7.2	0.3	3.6	6.4	1.1
Electron microscopes	6.6	8.9	1.6	5.5	6.7	1.7
Other microscopy equipment	0.3	1.1	0.2	1.0	2.9	0.8
Bioanalytical instruments	1.1	2.0	0.5	3.7	6.5	1.7
Cell sorters/counters, cytometers	3.4	12.5	1.4	4.7	6.9	2.9
Centrifuges and accessories	1.1	1.6	0.4	3.8	4.8	1.6
Chromatographs and elemental analyzers (except CG-MS)	0.6	2.3	0.3	3.0	8.4	1.6
DNA/protein synthesizers/ sequencers/analyzers	2.4	6.5	1.1	3.4	8.4	1.6
Growth/environmental chambers	0.5	1.9	0.4	2.0	6.9	1.7
Scintillation/gamma radiation/ counters/detectors	1.1	1.8	0.5	5.9	9.4	2.3
Other	1.1	2.6	0.9	2.9	6.4	2.6
Electronics equipment (cameras, recorders, etc.)	0.7	1.7	0.6	2.6	6.5	2.2
Temperature/pressure control/ measurement equipment	1.0	1.4	1.0	4.3	6.9	3.8
Lasers and optical/motion analysis equipment	1.8	5.3	1.5	3.9	9.5	3.3
Major prototype instrument systems**	4.6	8.9	4.3	3.6	4.3	3.5
Other	0.5	2.0	0.4	1.6	5.3	1.3

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

NOTE: Details may not sum to totals due to rounding.

SOURCE: National Science Foundation, SRS

Table 12. Percent of academic research instruments that are "adequate to meet research users' needs," by system age and type of equipment, 1988-89*

Type of equipment	System age			
	Total	0-2 years	3-5 years	6+ years
	(Percent of systems that are adequate for research)			
Total	89%	94%	89%	83%
Computers and data handling equipment	80	88	72	69
Graphics/CAD/image analysis equipment	72	82	50	81
Other systems ≥ $200,000	66	86	57	36
Other systems/components < $200,000	82	89	76	68
Spectroscopy and light measurement equipment	89	97	93	81
Electron/auger/ion scattering	82	98	88	70
Infrared/FTIR/laser Raman	91	99	91	79
Mass/GC-MS	84	95	89	65
NMR/magnets	86	94	82	84
Ultraviolet/UV-VIS	88	99	95	76
X-ray (diffractometers, etc.)	82	96	88	67
Other spectroscopy equipment	95	97	97	92
Microscopes and accessories	89	93	97	82
Electron microscopes	76	82	95	68
Other microscopy equipment	93	94	98	88
Bioanalytical instruments	93	98	96	87
Cell sorters/counters, cytometers	94	100	86	100
Centrifuges and accessories	95	97	99	88
Chromatographs and elemental analyzers (except CG-MS)	94	98	94	89
DNA/protein synthesizers/sequencers/analyzers	97	100	99	83
Growth/environmental chambers	87	99	79	78
Scintillation/gamma radiation/counters/detectors	91	100	98	86
Other	91	95	94	84
Electronics equipment (cameras, recorders, etc.)	89	94	92	76
Temperature/pressure control/measurement equipment	94	99	95	87
Lasers and optical/motion analysis equipment	90	89	95	84
Major prototype instrument systems**	84	95	88	71
Other	93	97	95	88

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

SOURCE: National Science Foundation, SRS

Table 13. Percent of academic research instruments that are in "excellent" working condition, by system age and type of equipment, 1988-89*

Type of equipment	System age			
	Total	0-2 years	3-5 years	6+ years
	(Percent of systems that are in excellent working condition)			
Total	60%	76%	62%	40%
Computers and data handling equipment	61	72	54	41
Graphics/CAD/image analysis equipment	59	70	51	44
Other systems ≥ $200,000	68	79	70	39
Other systems/components < $200,000	62	72	53	40
Spectroscopy and light measurement equipment	55	79	63	35
Electron/auger/ion scattering	45	89	38	22
Infrared/FTIR/laser Raman	57	63	69	38
Mass/GC-MS	65	84	69	37
NMR/magnets	42	62	52	31
Ultraviolet/UV-VIS	56	78	60	38
X-ray (diffractometers, etc.)	57	79	72	33
Other spectroscopy equipment	57	86	66	38
Microscopes and accessories	72	87	78	60
Electron microscopes	40	42	63	33
Other microscopy equipment	81	94	80	72
Bioanalytical instruments	61	77	68	38
Cell sorters/counters, cytometers	82	82	80	83
Centrifuges and accessories	70	90	75	42
Chromatographs and elemental analyzers (except CG-MS)	58	74	62	33
DNA/protein synthesizers/ sequencers/analyzers	57	39	75	69
Growth/environmental chambers	59	71	66	33
Scintillation/gamma radiation/ counters/detectors	49	87	59	34
Other	60	77	59	40
Electronics equipment (cameras, recorders, etc.)	63	86	52	34
Temperature/pressure control/ measurement equipment	55	73	53	37
Lasers and optical/motion analysis equipment	59	71	55	47
Major prototype instrument systems**	50	63	62	30
Other	62	78	66	42

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

SOURCE: National Science Foundation, SRS

Table 14. Percent of academic research instruments that are considered "state-of-the-art," by system age and type of equipment, 1988-89*

Type of equipment	System age			
	Total	0-2 years	3-5 years	6+ years
	(Percent of systems that are state-of-the-art)**			
Total	35%	51%	34%	15%
Computers and data handling equipment	23	32	13	9
Graphics/CAD/image analysis equipment	26	41	12	12
Other systems ≥ $200,000	24	42	11	.
Other systems/components < $200,000	22	31	14	9
Spectroscopy and light measurement equipment	31	57	38	11
Electron/auger/ion scattering	38	75	29	19
Infrared/FTIR/laser Raman	37	63	36	6
Mass/GC-MS	34	64	29	2
NMR/magnets	18	53	16	6
Ultraviolet/UV-VIS	29	40	47	7
X-ray (diffractometers, etc.)	35	68	36	9
Other spectroscopy equipment	32	55	40	17
Microscopes and accessories	37	65	47	15
Electron microscopes	20	48	31	10
Other microscopy equipment	42	68	49	18
Bioanalytical instruments	36	59	40	11
Cell sorters/counters, cytometers	23	79	7	4
Centrifuges and accessories	44	57	55	17
Chromatographs and elemental analyzers (except CG-MS)	32	57	25	8
DNA/protein synthesizers/ sequencers/analyzers	60	58	61	65
Growth/environmental chambers	45	72	39	9
Scintillation/gamma radiation/ counters/detectors	18	55	25	4
Other	43	58	44	24
Electronics equipment (cameras, recorders, etc.)	43	52	42	27
Temperature/pressure control/ measurement equipment	47	58	54	29
Lasers and optical/motion analysis equipment	40	58	37	20
Major prototype instrument systems***	40	61	37	22
Other	44	62	47	22

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*Data refer to instrument systems originally costing $10,000 to $999,999 that were used for research in academic settings in 1988 (in engineering, the physical sciences, and computer science) or in 1989 (in the agricultural, biological, or environmental sciences). Instruments used only for instruction are excluded.

**State-of-the-art is defined as "the most highly developed and scientifically sophisticated instrument of its kind." The assessment was made by the principal investigator with primary responsibility for the instrument.

***Includes ships, planes, nuclear reactors, wind tunnels, MBE systems, and other systems ≥ $100,000 not classified elsewhere.

SOURCE: National Science Foundation, SRS

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